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NATIONAL GEOGRAPHIC MAGAZINE

STUDIES OF

MUIR GLACIER, ALASKA

HARRY FIELDING REID

WASHINGTON

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FRONT OF MUIR GLACIER AND MOUNT CASE, LOOKING EASTWARD.

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STUDIES OF MUIR GLACIER, ALASKA.

BY HARRY FIELDING REID.

[Accepted for publication December 12, 1891.]

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ILLUSTRATIONS.

Introduction and Narrative.

A desire to see the Alaskan coast more thoroughly than is possible to ordinary tourists led to the formation of a party to spend the summer of 1890 encamped there.

The description of Muir glacier by Professor Wright* turned our attention to that point. Its accessibility and the interest

*The Ice Age in North America, 1889, chap. iii.

awakened by its reported motion of 70 feet a day decided us to camp at its mouth and study the glacier and its neighborhood as thoroughly as time would permit. The first requisite was a reliable map of the region. None such existed, and we determined to devote much time to a survey and to make a map which would show with some accuracy the extent and form of the glacier and the positions of the mountains which surmount it, and also serve to determine what changes may take place in the future. We also planned a careful measure of the motion of the ice, a determination of the magnetic elements, a regular meteorologic record, a study of the geology of the region, a collection of plants, and observations of all indications of change in the extent of the glacier, the amount of glacial erosion, etc.

The party consisted of Mr H. P. Cushing, who took charge of the meteorologic records, the geologic observations, and the collection of plants; Messrs H. McBride, R. L. Cawcroft, J. F. Morse, C. A. Adams, and the writer. It gives me pleasure to acknowledge that it would have been impossible to accomplish the work if it had not been for the cheerful and efficient aid which all my companions rendered.

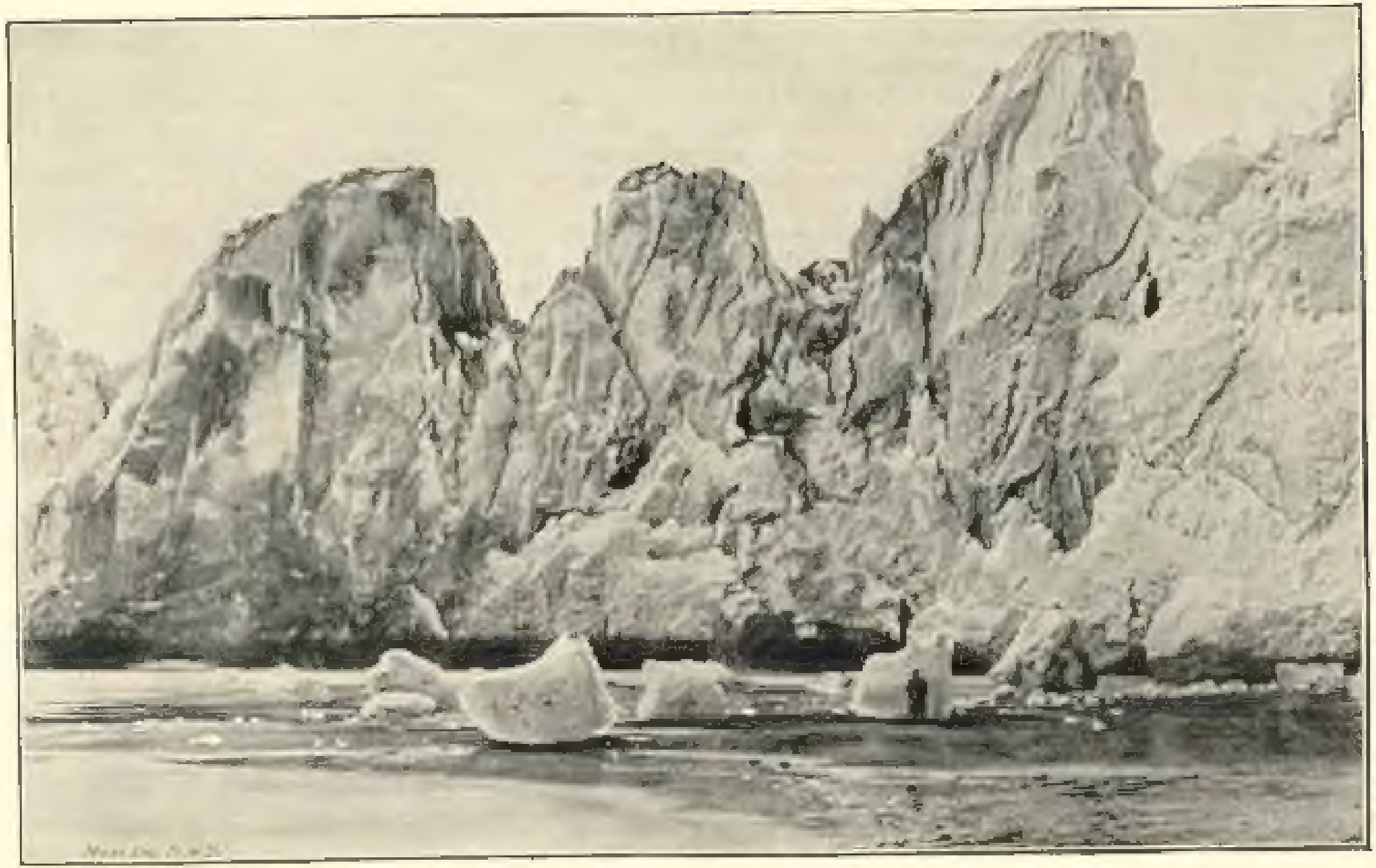
Muir glacier seems to have been known only to the Indians until 1879, when it was visited by Professor John Muir and Reverend Mr Young; but they were prevented by bad weather from much exploration. In 1880 Professor G. F. Wright devoted a month to its study. We are indebted to him for a very interesting description. Until our visit, in 1890, these were the only attempts to obtain any accurate knowledge of the glacier. Glacier bay offers the luxury of exploration. Visited weekly during the summer by the steamers of the Pacific Coast Steamship company, the explorer can take with him everything necessary to his comfort, can renew supplies when necessary, can receive and despatch his mail, and still be in a region of which little is known—a region of great interest to the geologist and student of physical geography. It seems strange that it is not more thoroughly studied.

On July 1st the *George W. Elder* cast anchor in Muir inlet, not far from the glacier, and landed our instruments, tents, personal baggage, and provisions on the eastern shore. We found Professor Muir and Mr Lamb encamped there. They had come also to study the glacier, and added much to the pleasure of our stay. We immediately set to work to put up our tents, and

before evening everything was in good shape. We brought boards from Juneau for flooring, tables, etc., which added materially to our comfort and convenience. A bookshelf held our small library of works on glaciers, logarithmetic tables, etc. A gasoline stove enabled us to cook our meals with ease, and ruppercloth permitted us to eat them in comfort. This was to be our base-camp, and, in honor of Professor Muir, we named it *camp Muir*. Here we stayed until the middle of September, making various excursions of several days' duration to points too distant to be visited in one day, always, however, leaving two of our party at camp to make the meteorologic observations. We had with us a row-boat 18 feet long, provided with a sail, and during our stay we bought from the Indians a small dugout canoe which would carry three persons.

On one occasion, in company with Professor Muir, we rounded the western headland of Muir inlet and pushed a mile or two up Glacier bay. The water was so full of floating ice, in pieces large and small, that our progress was very slow, and we finally landed for the night, hoping to find clearer water the next day. In this we were disappointed, and therefore rowed back again and crossed the bay to the large island opposite Muir inlet. It was in this limestone island that Mr Cushing found the fossils which make it probable that these rocks are of Paleozoic age. Later in the evening we returned to camp Muir. On another occasion, following Professor Muir's example, we made sleds on which we packed our blankets, provisions, and instruments, and spent five days exploring and mapping the eastern part of the glacier. We ascended Tree mountain (2,740 feet) and Snow dome (3,580 feet), which, though of moderate elevation, commanded excellent views. Another time we visited the stations marked *N* and *T* on the accompanying map (plate 14), and ascended one of the peaks just to the westward. We also ascended Pyramid peak, approaching it by the valley of the Dying glacier. The weather unfortunately was misty, so that we added little to our knowledge of the mountains toward the west, except to see that they were numerous and did not seem to surround any very large valleys like that occupied by Muir glacier.

Shorter excursions were made on all clear days to points more easily accessible. Among these the most interesting were connected with the measure of the motion of the ice. To plant our flags where we wanted them required us to make a way among



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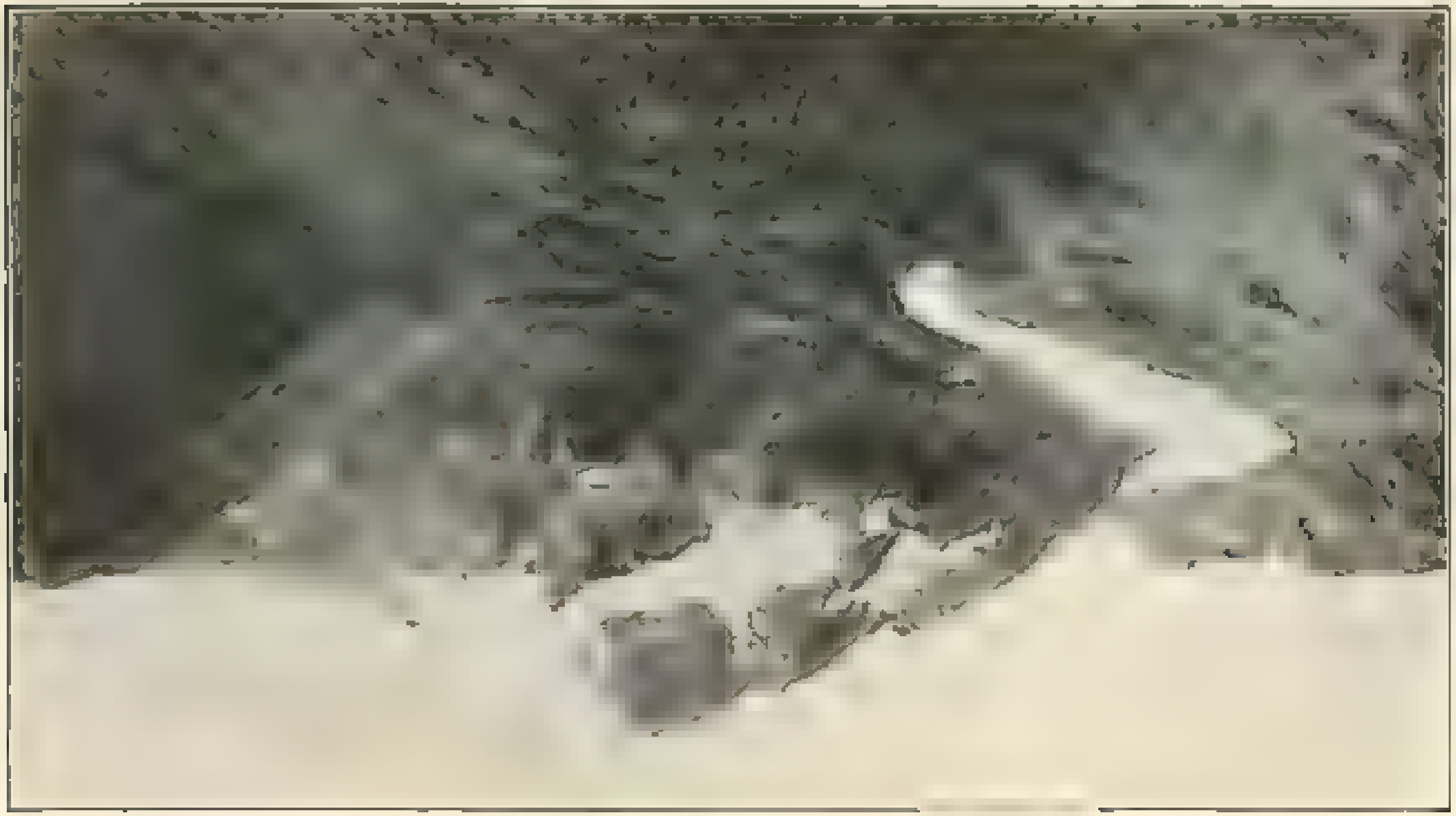


[illegible]

[illegible]

[illegible]

[illegible] of the glacier [illegible]. [illegible] shallow lakes, and [illegible] deep ravines mark the positions of former streams. The western sub-glacial stream has cut a gorge through the plateau, and exposed the buried forest described by Professor Wright (see page [illegible]). [illegible] underneath [illegible] the plateau ends [illegible] water side [illegible] a steep [illegible] to a narrow beach only covered by the highest tides. On the eastern side the terraces extend for half a mile or more; the upper surface of the plateau is but a [illegible] feet [illegible] down to the level of the glacier stream at the foot of the [illegible]. This stream [illegible] South of the [illegible] deposits slope gradually up from the beach to a height of about [illegible] feet against the mountain side.*

The [illegible] depth [illegible], Professor Wright reports soundings by Captain Hunter of [illegible] feet, about 1,000 yards south of the present position of the ice front [illegible] found [illegible] within a hundred yards of the ice front [illegible] 720 feet. This does not necessarily [illegible] that the [illegible] increases in depth as we approach the [illegible] the [illegible] deepest part of the [illegible].

[illegible]

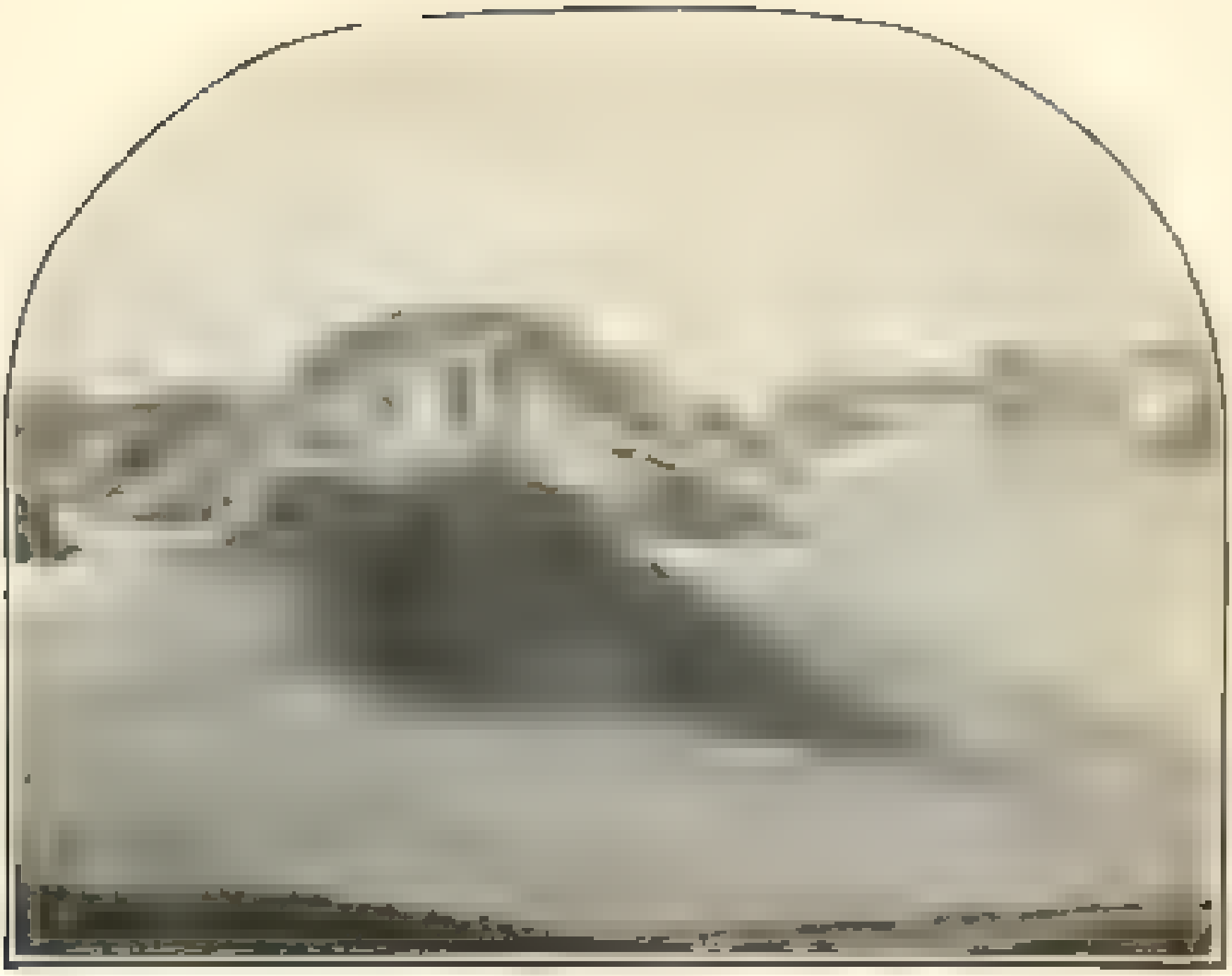
Muir glacier [illegible] depression [illegible] the mountains [illegible] long and [illegible]. It is fed by a great number of tributaries, of which the first [illegible] north [illegible] the northwestern [illegible] the largest. These [illegible] [illegible] The general slope of the [illegible] between the [illegible] about [illegible]. The appearance of the glacier toward the northwest [illegible] the slope there [illegible]. The total area drained by this system is about [illegible] square miles [illegible] of [illegible] about [illegible] square [illegible]. The area draining into Muir [illegible] is about

* For a [illegible] description of [illegible] deposits see "Notes on the [illegible] [illegible]" by Mr. [illegible], [illegible], vol. [illegible], [illegible] pl. [illegible].

[illegible]

Beginning at the right, we find three tributaries coming in from the northeast. The first glacier (see plate 4) sweeps around in a great curve from behind mount Wright; its lower part is completely covered with debris for fully a mile and a half from its mouth; above this the glacier is particularly clean. The White glacier (see plate 4), which joins the Muir just below mount Case, is remarkably beautiful. Arising in a circus of snowy mountains it flows down a long narrow valley at a slope of about 10°, its perfectly white surface marked by the wonderfully symmetrical parallel curves of three or four dark moraines. It is about four miles long and half a mile wide. A little farther is the southeastern tributary (see plate 5), fed by a number of smaller glaciers. This glacier is itself bounded on the [illegible]; it crosses a divide east of [illegible], over which the ice flows into another valley on the other side. This divide has an altitude of 2,500 or 2,600 feet. About ten miles southeast of our camp a large glacial stream discharges into Glacier bay. It rises among the southern peaks of the mountains which bound these three tributaries.

Still farther eastward is Main valley, which, though it probably once contained a tributary, is now no longer part of Muir glacier. The ice flows down this valley to a distance of three miles with apparently a very slow motion. A few miles down the valley the ice ends in a high wall facing Main lake, into which it occasionally discharges an iceberg. The stream draining this lake flows through a broad flat valley of sands and gravels toward the southeast, and finally empties into Lynn canal. The three valleys entering the eastern side of Main valley also have flat gravel-covered floors, through which run the streams from the snow fields and small glaciers at their heads. Two of these valleys are beyond the present termination of the glaciers. Formerly the ice must have extended across their mouths, damming the streams and converting them into lake beds. The upper valley is now in just this condition. The lake which occupies it has been named Berg lake on account of the great number of icebergs in it and in the winter of 1890. Just north of the settlement is Dirt glacier, so called on account of the moraine which completely covers it (see plates 6 and 11). It can be seen from the end of Muir glacier, but is so far distant that one



[illegible] snow which are too small and too low to supply ice for a [illegible] of these glaciers, and are evidently melting away. At the western extremity it crosses over a divide and flows into a valley [illegible].

The mountains immediately surrounding Muir glacier are not high, the highest peaks being between 5,000 and 7,000 feet. The [illegible]

mount Wright,* mount Case† and Pyramid peak, are points [illegible]—the first two by their jagged crests marked by snow [illegible]; the last by its symmetry [illegible] and three by their [illegible]. The more distant mountains seem to me somewhat [illegible], but this is largely due to their distance, for they are from fifteen to thirty miles away. And it [illegible] I think, as if the western are scarcely lacking in picturesqueness. If we climb [illegible] the three old peaks of mount Young show themselves over [illegible] and the broad snow-covered [illegible] of the northwestern tributary can be [illegible]

Surface of the Glacier.

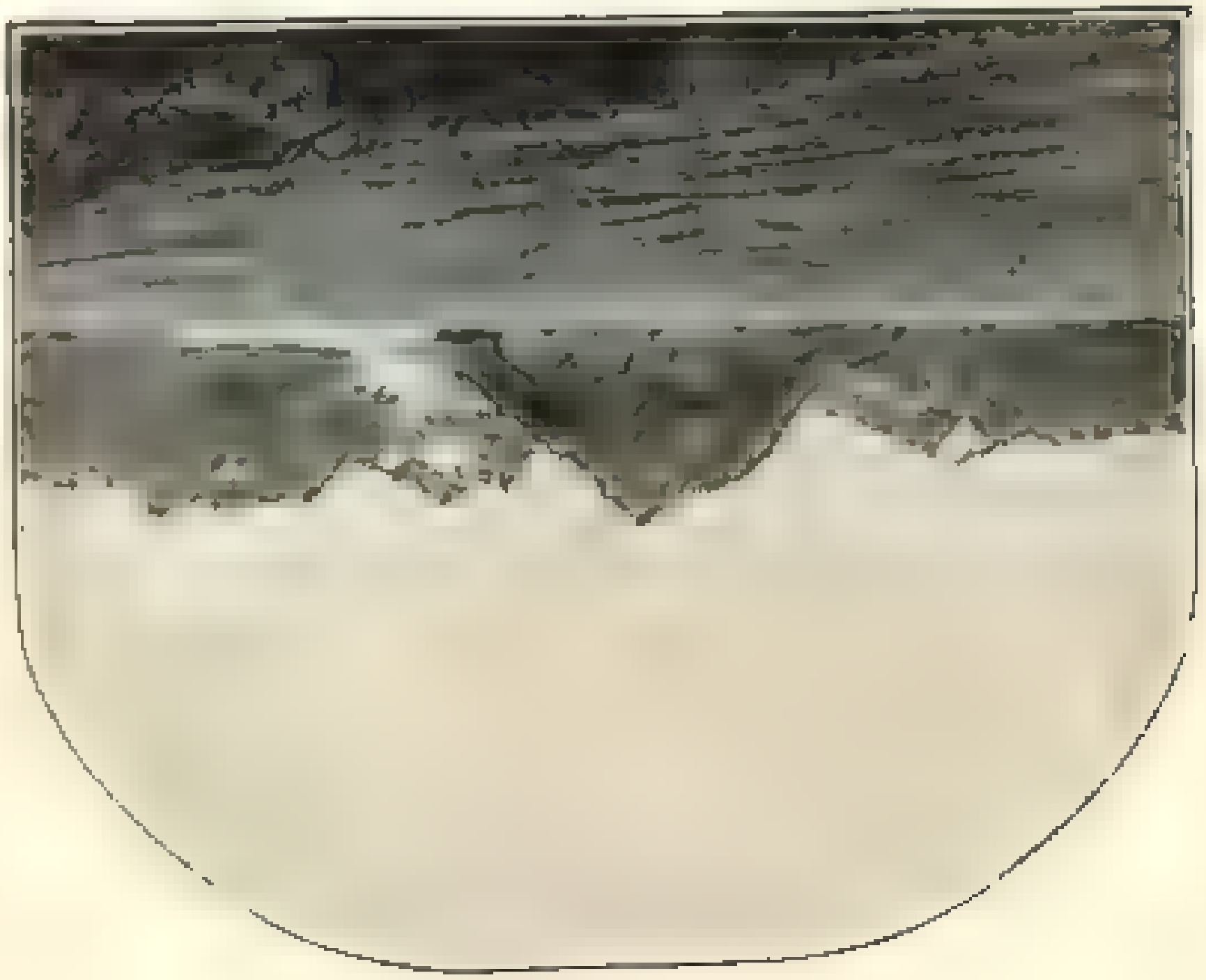
The surface of the ice presents the [illegible] appearance of [illegible] under the foot, making walking [illegible] very [illegible] This surface varies very much with the weather. Sometimes after rain the ice was firm [illegible] the [illegible] appearance.

Crevasses.

The eastern part of the glacier was free from all large crevasses; none in this part were too large to be stepped over. [illegible] appeared as small [illegible] small [illegible]. That there is, however, is also small [illegible] which show that at [illegible] all the [illegible] from the eastern part of the glacier is crowded through a narrow space between the ice-front and the mountain to the east, still the greatest motion here is only about two [illegible] (fig. 45). The amount of crevassing in the other parts of the

* Named after Professor G. Frederick Wright, who spent a month [illegible] studying Muir glacier in 1886. [illegible] his Ice Age in North America, chap. [illegible]

† Named after the Case School of Applied Science, Cleveland, Ohio.



Mountain and Plain

In the Rocky Mountain region the Cretaceous and Tertiary formations are commonly found in the form of broad, gently inclined plains, which have been deeply trenched by the streams that flow from the mountains. The mountains rise abruptly from the plains, and the boundary between the two is usually a well-defined line. Where the beds of the plains are nearly horizontal, the mountains are commonly composed of tilted beds, and the boundary between the two is a fault scarp. Where the beds of the plains are inclined, the mountains are commonly composed of folded beds, and the boundary between the two is a monocline. Where the beds of the plains are horizontal, the mountains are commonly composed of folded beds, and the boundary between the two is a fault scarp. Where the beds of the plains are inclined, the mountains are commonly composed of folded beds, and the boundary between the two is a monocline.

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After falling into a crevasse, the water sometimes reaches the end of the glacier, and sometimes flows along a channel in the ice. We saw a very good example of such a channel. When we first came to the glacier, early in July, there was a large opening like a sewer in the face of the ice-front near the eastern end, [illegible] fifty or a hundred feet above tide-water, from which issued a strong stream of very muddy water. The opening must have been 400 square feet in cross-section. [illegible] all was [illegible] the stream. Now, muddiness is a characteristic of water which has flowed along the bed of a glacier, [illegible] clearness of the surface water; I therefore infer that this stream was part of the water which flowed along under the ice [illegible] side of the glacier and was diverted [illegible] crevasse which ends in the ice-front. During one day the mouth of the stream [illegible] it was [illegible] level with the water of the inlet. This may have been due to either of two causes: (1) the course of the channel may have been upward as it approached the ice-front, so that as the ice [illegible] broke away the [illegible] exposed was at lower levels; or (2) the stream may have [illegible] itself by cutting [illegible] (see page [illegible]).

On each side of the inlet large streams issue from the end of the ice at a number of points, and [illegible] between [illegible] forming [illegible]. These streams were about [illegible] feet wide and [illegible] feet deep. The current is so swift that they roll down stones as large as [illegible], but [illegible] they carry off [illegible] form of fine mud. We [illegible] water largely [illegible] and found that although [illegible] would precipitate [illegible] a few hours [illegible] the water [illegible] three or four days. The muddy character of the water [illegible] the ice-front shows that another stream must discharge at that [illegible] under or through the ice. A small part of the drainage of the glacier passes down Muir valley, but [illegible] not amount to very much. I think the principal sources of the streams in this valley are from the snow-fields and smaller glaciers on the sides.

Moraines and [illegible] Cones.

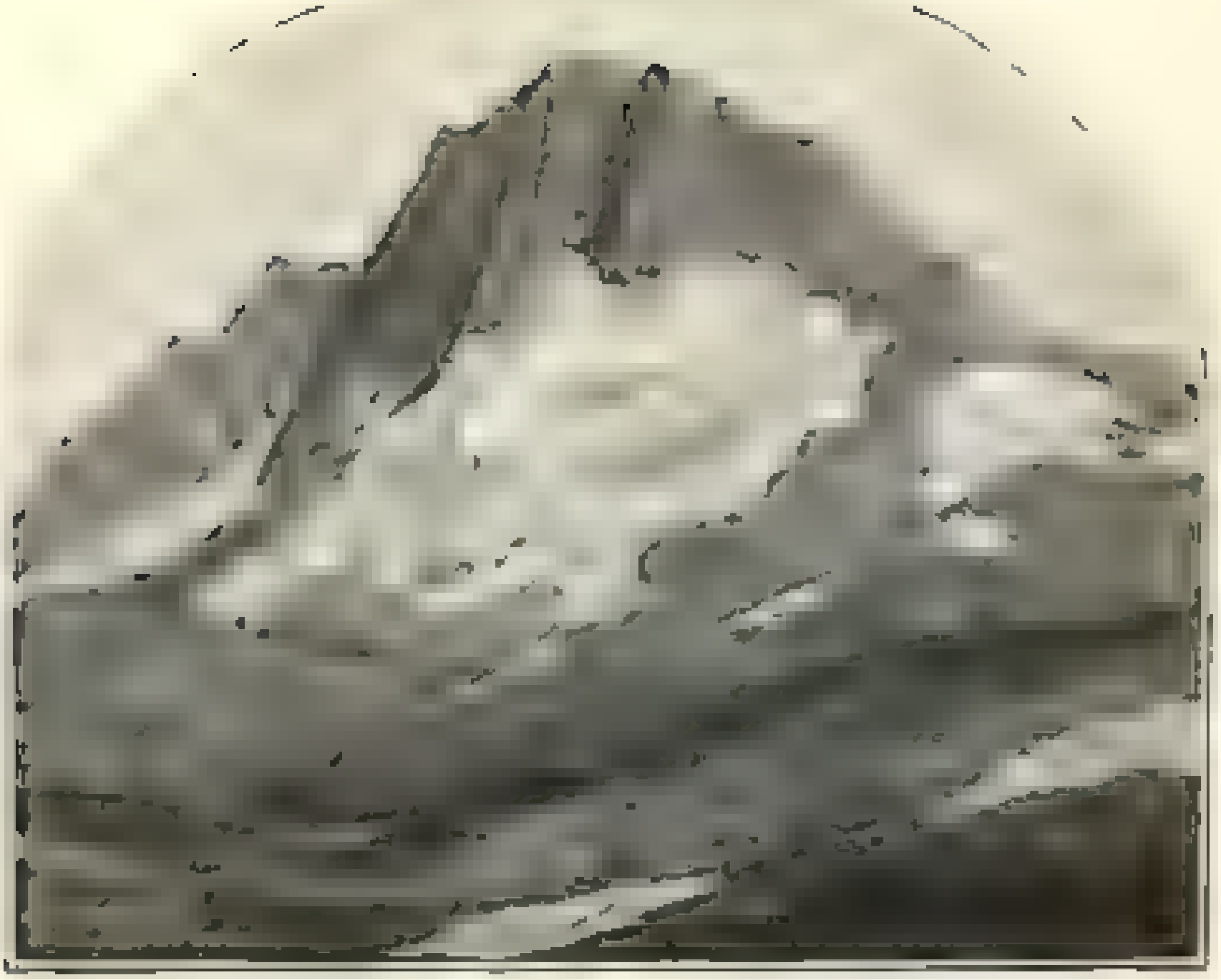
The moraines of Muir Glacier, seen from an elevation, are very striking. Coming from many quarters, they sweep in [illegible] between

westward and then southwest over the preceding wedge. [illegible] the nunatak [illegible] of these moraines [illegible] glacier [illegible] Mr. [illegible] nunatak [illegible] dark [illegible] light [illegible] rock [illegible] of the same rock as the nunatak [illegible] moraine feeding from the east side of [illegible] come to an end about half-way between [illegible] explanation of these moraines appears on page [illegible]. The [illegible] are like those with which we are familiar on other glaciers [illegible]. The largest [illegible] glacier tables [illegible]

The moraine [illegible] is a long sharp ridge, the [illegible] of which is [illegible] by a thin covering of stones of small size. There are two other similar ridges between these and the side of the glacier, which, however, are not connected with nunataks. All the larger stones seem to have rolled [illegible] and left only the smaller fragments. [illegible] nunatak G we found [illegible] very curious cones of rolled stones. The stones were about the size of hen's eggs and rested on the ice beneath, just at the angle of repose, so that the slightest [illegible] caused [illegible] to roll down. These stones were rounded, and they presented exactly the appearance of having been [illegible] about by running water. There [illegible] some agent [illegible] been at work [illegible] larger pieces. Perhaps they were collected by a stream [illegible] carried them [illegible]. Other cones [illegible] these, [illegible] not composed of similar material.

Evidences of [illegible] of the Glacier.

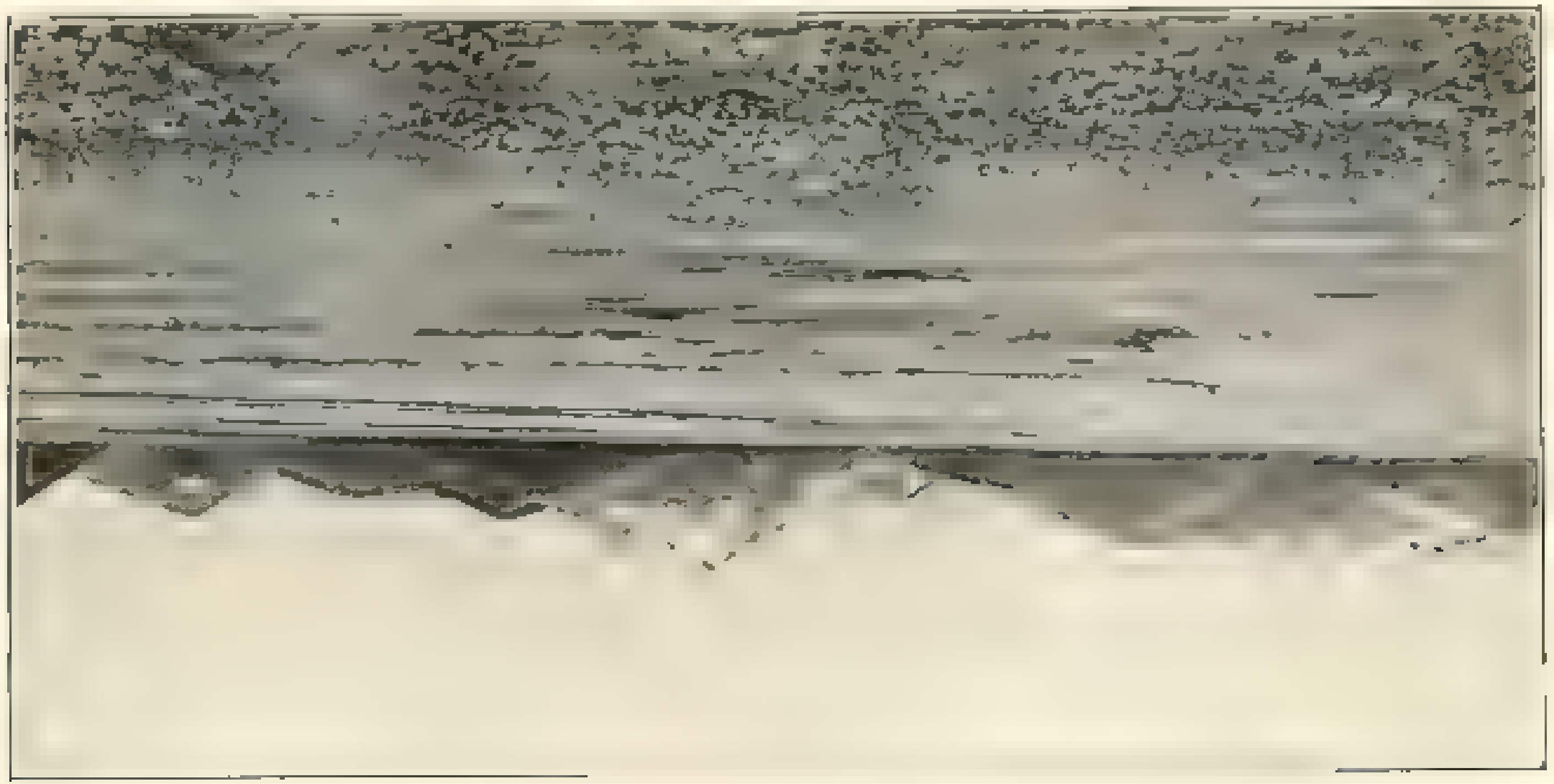
Professor Wright has pointed out [illegible] that Muir glacier has been much larger [illegible] than it is at present. The existence of striae, rounded knobs, and glacial [illegible] at points considerably above the present end of the glacier show the first; the existence of the buried forest [illegible] of Muir [illegible] of old logs on some of the [illegible] show [illegible]. He has [illegible] the following



evidence to show that the glacier is at present retreating, and that its retreat is quite rapid. [illegible] The absence of forests on the upper part of the [illegible] bay, the existence of fresh striae and [illegible] in situations where the material would not [illegible] resisted erosive agencies for any great length of time, the small amount of debris fallen from the [illegible] the eastern side of the inlet, the small amount of vegetation on the slopes near the glacier, the transverse ridges on the [illegible], the mass of [illegible] melting ice in front of the [illegible] small [illegible] which make it probable that a large part of Glacier Bay was filled with ice [illegible] years ago.*

To these evidences I may add the following observations. On the sides of the mountains bordering the glacier, and [illegible] in the gullies on the eastern slopes, there are masses of ice standing a hundred feet or more above the present level of the glacier. This ice has been protected from very rapid melting by the debris which covers it. It must have been a connected part of the glacier not many years ago. On the [illegible] side of [illegible] mountain there is a spur which projects into the [illegible] of Muir valley. [illegible] upper end [illegible] the [illegible] lower end [illegible]. Across this spur in a direction parallel to the valley were some small stream courses, beginning abruptly at the upper ends, where [illegible] have been the [illegible] when it was level with the top of the spur. The whole spur was covered with [illegible] and [illegible] debris. [illegible] the disposition of the sand. The fine [illegible] have been washed away by the [illegible] if the spur had been [illegible] many years. The [illegible], to the west is at a higher level than the western or north-western tributaries and slopes both toward the north and the south. As this region is not [illegible] of supply, it must have obtained [illegible] from the north-western or western tributaries, which therefore must have been at a higher level than they are now. If [illegible] had been [illegible] melting, the surfaces of these two tributaries would [illegible] more rapidly than [illegible]. We are therefore forced to conclude not only that the [illegible] is melting away, but also that it is [illegible] away. This process has

* [illegible] North America, [illegible] pp. [illegible]



A report on the work of the Royal Society

Examples of the Sun's Attraction upon a Mountain of Matter

some of the stumps would have been planed down and these features obliterated. We must, however, equally well look [illegible] for a very [illegible] period.

The trees of the buried forest (see plate 12) must have grown when the glacier was smaller than it is now. The sand and gravel was then carried in among them and later the [illegible] over the sand. Now, these trees are most probably of the same species as the [illegible] now growing in the [illegible] (see supplement [illegible]), and therefore it seems we should [illegible] have elapsed since they were alive [illegible] rather than thousands of years. Another evidence lies in the logs found on [illegible] mountain slopes. [illegible] Where [illegible] the moraine [illegible] from the [illegible] of the [illegible], [illegible] the east [illegible] of Muir [illegible] west of the stream, in the gully east of [illegible], and [illegible] on the northeastern side of [illegible], in fact, over most of the [illegible] and the southeastern part of the glacier [illegible] these [illegible] covered with debris, [illegible] which has apparently protected them from being ground up [illegible]. Now, it hardly seems possible that the wood [illegible] would have been carried away long ago if the [illegible] had not been comparatively recent.

[illegible] the advance the glacier must have been very [illegible] than at present, for [illegible] the region [illegible] the forest [illegible] tributary, which is now bare and [illegible], to [illegible] trees, and it must have remained [illegible] for several hundred years to allow [illegible] of the [illegible] forest, some of which are two feet or more in diameter, [illegible]. A piece of one of these [illegible] 22 [illegible] in thickness [illegible], which would give a rate of growth of one inch in diameter in 34 years. [illegible] the tree, [illegible] later years. The wood was from the [illegible].

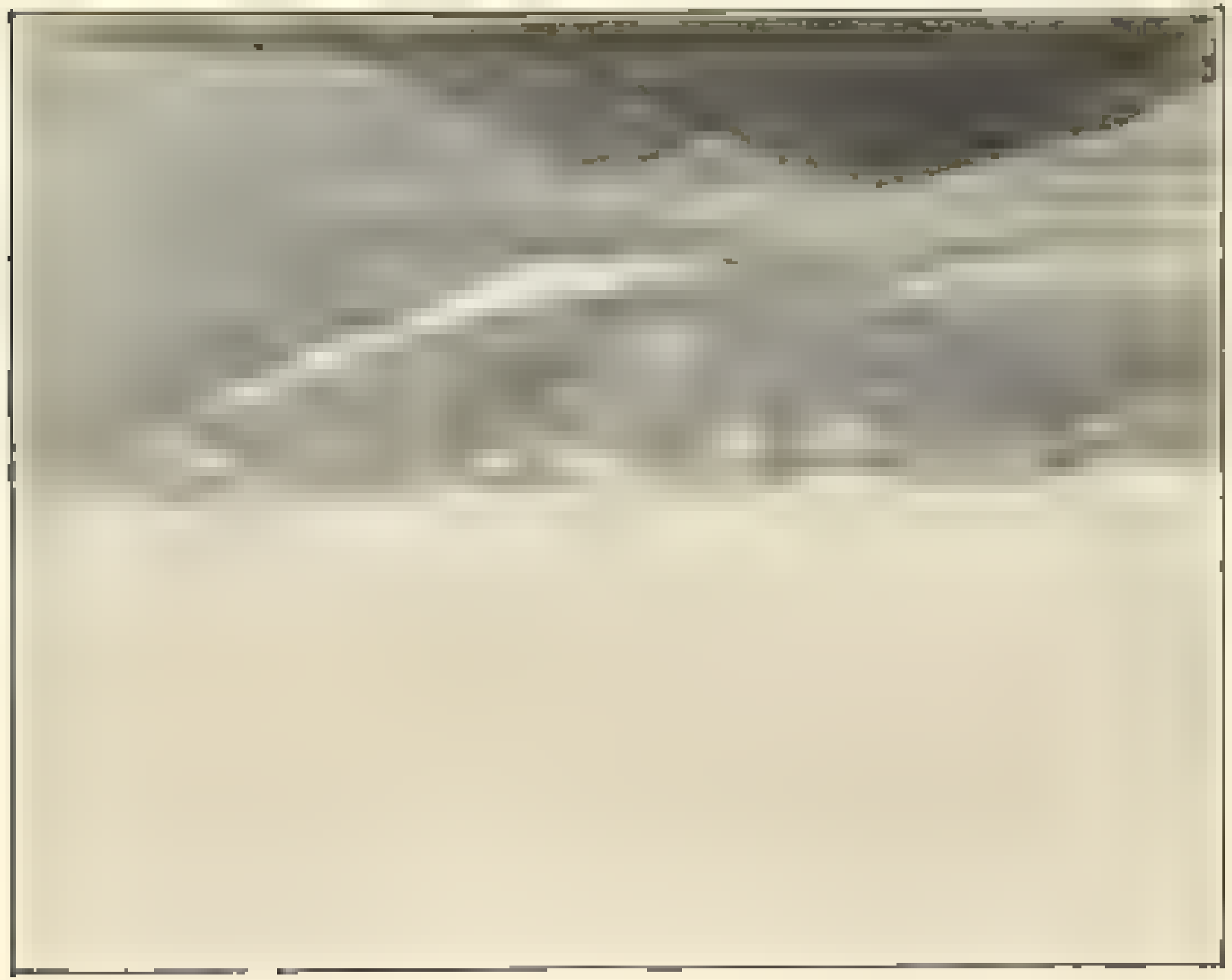
Although the evidence [illegible] a short duration for the last advance of the glacier [illegible], the [illegible] seems to be [illegible]. Probably the principal [illegible] against it is that the changes are [illegible] more rapid than any we are familiar with [illegible], however, [illegible] collected by [illegible] Agassiz, [illegible] the [illegible] ages [illegible]

in the fourteenth to the sixteenth centuries the glaciers of the Alps were much less extensive than at present, and that horses were able to cross passes now covered with névé. Gradually [illegible]. During the seventeenth and eighteenth centuries the glaciers increased, attaining their greatest extent in the beginning of this century.* At present they are in general retreating. This shows a variation of the glaciers [illegible] almost as rapid as that found for the glaciers of Glacier bay.

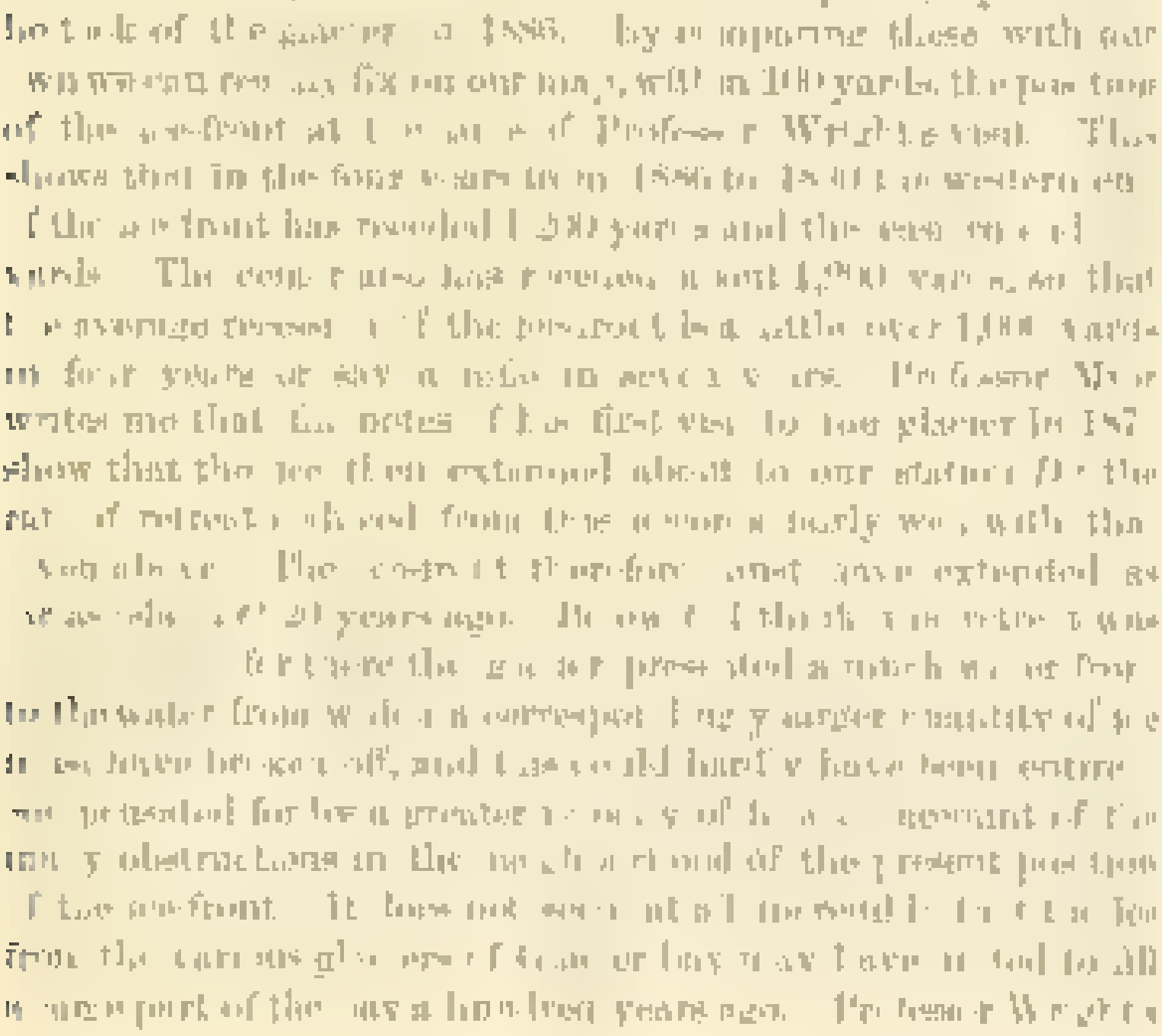
A possible Cause of the recent Retreat.

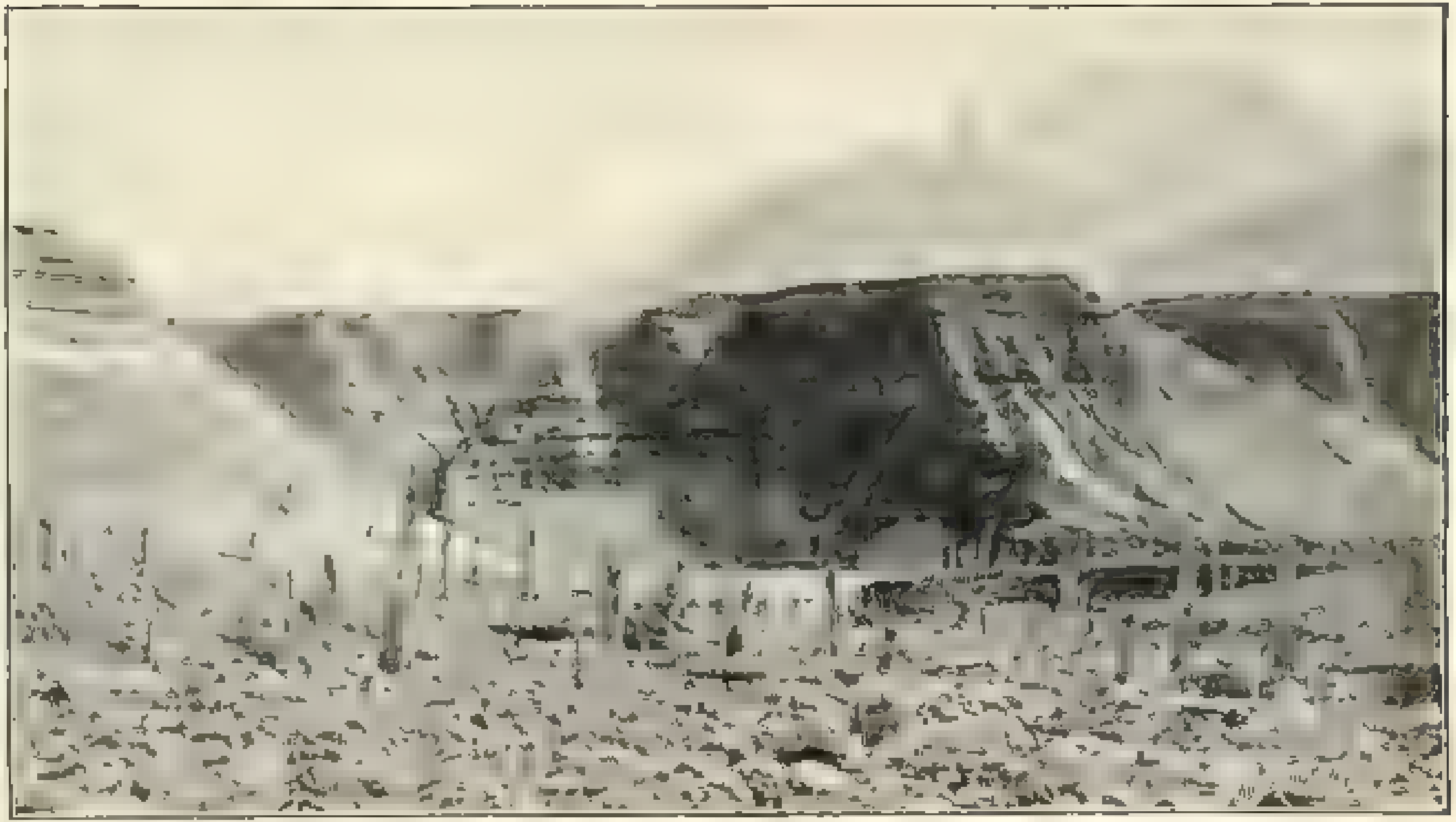
Along the shore in Muir inlet is very low; one finds, most of the eastern shore, stumps of large trees, which Professor Muir assures me are in place. The trees must have grown at some distance above high tide; they are now twenty feet below that level. Although I cannot say so with certainty, it is not unreasonable to suppose that these trees, like those of the buried forest, are spruce, and of the same species as those now growing in Alaska. But we must remember that any result obtained from this supposition have no more weight than the supposition itself. If, therefore, these trees were growing at the same time as those of the buried forest, there has been a subsidence of the land of at least 20 feet since the last advance of the glacier; it may have been much more; if so, it would have produced an increase in the mean annual temperature, which would have increased the rate of melting and would also have decreased the proportion of the solid to the liquid precipitation, and on account of the general lowering of the mountains, more of the moisture from the sea may have been carried over them and precipitated farther inland. All of these tend to diminish the extent of the glacier. Not only that, but the diminution itself would increase the rate of diminution, for the presence of extensive snowfields must lower the mean annual temperature (see page [illegible]), and thus increase the proportion of snow to the total precipitation. If for any cause these snow fields become smaller, their influence on the mean temperature becomes less, the snowfall is diminished, and the snow fields become smaller still. So we see that anything causing a slight change in the mean temperature may result finally in quite a large variation in the extension of the glacier, although this large variation may reach its limit long after the cause which started it has ceased to

* Agassiz, Études sur les Glaciers, 1840, chap. xv.



Formation of the Fatherland





Motion of the Ice

I had hoped to make an extensive series of measurements of its motion at different parts of the glacier, but [illegible] of other work and the great extent of the ice [illegible] the position of the [illegible] months. The ablation [illegible] was so great that we felt that careful precautions must be taken [illegible]. We [illegible] contented ourselves [illegible] series [illegible] flags whose [illegible] mistakes. The [illegible] part of the [illegible] deeply crevassed, and in [illegible] the proper precautions for planting the flags [illegible] the difficulties were [illegible] matters [illegible] first to the [illegible] the task of crossing the [illegible]. In this we were [illegible] flags we made five or six attempts, first from one side and then from the other. The farthest [illegible] from [illegible] about 500 yards apart, [illegible] interval is greater than [illegible] average interval between the flags; [illegible] was practically [illegible] period.

Two [illegible] sets of measurements were made: the first on a series of ten flags from July 21 to 24, the second on a series of [illegible] flags from August 4 to 8. The first three flags [illegible] were measured after the first set of observations [illegible] from July 21 to August 8, a period of 18 days, [illegible] determination of their daily rate. [illegible] the flags would [illegible] were [illegible] 18 [illegible]. The flags marked [illegible] belong to the first period, those [illegible] two [illegible] to the second; the others were observed [illegible] both. [illegible] were obtained from [illegible] between July 21 and 24. The flags were observed from A and B, which were 531 yards apart [illegible]. These were the most available points of observation, and, although they were not well situated for determining with high accuracy the actual positions of the flags, [illegible] positions [illegible] determined with [illegible] sufficient accuracy. [illegible] be determined from [illegible] observations [illegible] error of [illegible] to produce large errors in [illegible]. This, however, was [illegible] important, for the direction [illegible] given by the [illegible]

[illegible]

[illegible]


I
II
III

[illegible]

[illegible]

[illegible]

Plan of a Turn-under Railway

[illegible] the water which [illegible] the [illegible] more rapid [illegible] the [illegible] will be formed [illegible] and deeper [illegible] the water, [illegible] the slope of the bed, until the [illegible] of the water [illegible] break it off. The [illegible] in the future will [illegible] and the size of the [illegible] formed are [illegible]

[illegible] Erosion

The general [illegible] of [illegible] by glaciers [illegible] [illegible] generally [illegible] of [illegible] [illegible] and [illegible] [illegible] the [illegible] the rock of the [illegible] in places the bed-rock [illegible] where [illegible] had been broken and leaving holes which [illegible] water. Near [illegible] a lake [illegible] formed [illegible] 20 feet [illegible]

[illegible] on one side the rock rises vertically eight or ten feet above the water. The rock which formerly [illegible] separated [illegible] from the rock [illegible] in the passage [illegible] The rocks [illegible] in part [illegible] the [illegible] and [illegible] and carried [illegible] glacial streams [illegible] of glacial [illegible] [illegible] that [illegible] formerly occupied by glaciers.

Probably the best method available [illegible] the rate of erosion is to calculate the amount of [illegible] carried off by [illegible] glacial streams, as Professor Wright and [illegible] [illegible] more accurate [illegible] an average of [illegible] tons of [illegible] [illegible] the head of [illegible]

* [illegible] are given [illegible]

† The following [illegible] were [illegible] [illegible] drained [illegible] [illegible] area of glacier [illegible] If we [illegible] of bottom [illegible] from the [illegible]

[illegible]

ery fallen rock above on the surface of the glacier, and is probably due to the difference in rates of erosion of these [illegible]

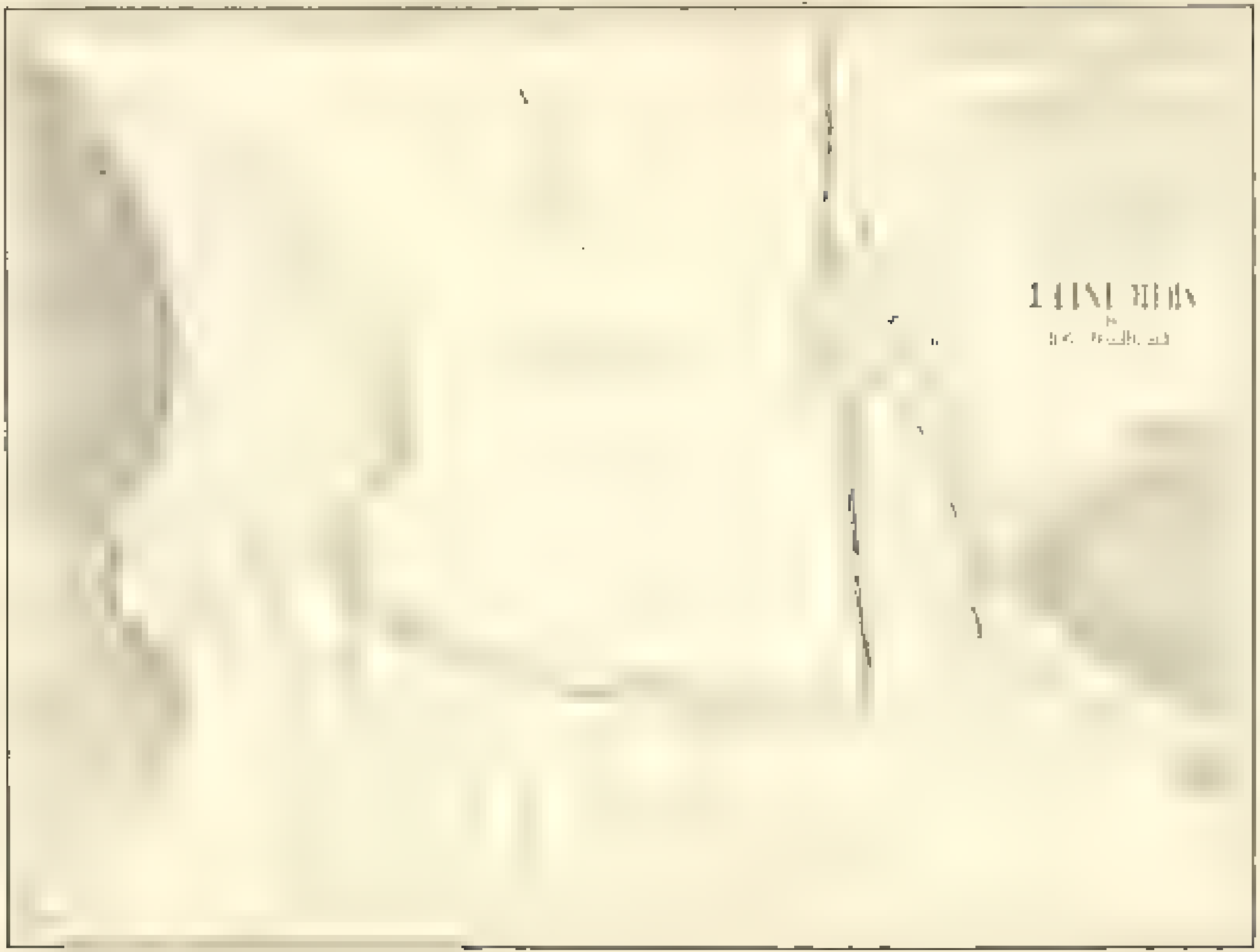
METEOROLOGICAL NOTES.

The prevailing wind on the Alaskan coast is from the south-west, but the glacier by cooling the air in contact with it produces a local wind which slides down the slope. There is [illegible] easterly wind blew on [illegible] days of our stay, [illegible] we had a strong northerly gale [illegible]. At [illegible] the wind was from the west and at [illegible] from the northwest; in fact, everywhere it flowed down the slope of the glacier. Its influence on the temperature was very marked. The mean temperature during July and August was 45°.3 F., about 10° lower than that at Juneau during the same period, although the latter place is only about [illegible] miles further southward. At no time during our stay, however, was a freezing temperature reached.

The cold wind did not usually extend very high; frequently, however, [illegible] moving northward not 1000 feet above our camp where the flag was streaming toward the south. The

FIGURE 5.—*Diagram illustrating Refraction.*

temperature was higher on elevations than lower down. At [illegible] feet the temperature was once observed [illegible] C. ([illegible] F.) higher than at camp; and at the same time, on the top of Tree mountain ([illegible]), the temperature was [illegible] C. ([illegible] F.) higher [illegible]. This increase of temperature with altitude we see at times [illegible] increased density in the cold temperature with a corresponding increase in refraction, leading to the mirage which is so common here. The rays which pass close to the observer and the object are in the cold layer. A ray of light may reach the observer after following a horizontal path of [illegible] rising slowly and then being refracted down again. The result is to make the object appear stretched and to give it increased height. We often saw islands with apparently vertical sides, [illegible] that in reality were [illegible] vertically [illegible]



Insectivorous plants

Two general sources of economic profit are represented in botanical work by the study of the [illegible] plants. The investigation of these is usually [illegible]

[illegible]

[illegible] by Mr. [illegible] of the United States Geological Survey [illegible] incorporated [illegible].

[illegible] United States Geological Survey for [illegible] kindness in [illegible] the [illegible] necessary for the [illegible].

[illegible] first, because a preliminary examination showed that [illegible] the [illegible] of the rocks [illegible] petrographic [illegible] description of [illegible].

[illegible] in regard to the [illegible] or geologic association [illegible].

The [illegible] interest of the rock collection consists in the light [illegible] on the nature of the Alaskan [illegible] which are for the present at least inaccessible to the geologist, and in the strong similarity between these [illegible] and the rocks which have been more carefully studied from portions of [illegible] [illegible] years.

[illegible] specimens [illegible] small [illegible] the [illegible] of [illegible] we [illegible] correspondence [illegible] Arctic [illegible] regions farther southward [illegible] rocks [illegible] identical with those [illegible] the [illegible] [illegible] In the [illegible] petrographic descriptions [illegible] distinguish between [illegible] crystalline [illegible] rocks [illegible] structure [illegible] masses and the finer [illegible] the most part [illegible] crystalline [illegible] rocks.

These [illegible] types pass almost [illegible] gradually into one another [illegible] sharp [illegible] and yet, for convenience of description, rather than because they stand for any petrographic [illegible] groups, they may be ranged under [illegible].

[illegible] U. S. Geol. Survey [illegible]

these rocks [illegible] porphyrites [illegible] (dio-rites?)*

[illegible] ROCKS

Not only does the structure of the specimens [illegible] examined by [illegible] from Alaska [illegible] that [illegible] under very different physical [illegible] from the more finely granular porphyrites [illegible] their characteristics [illegible] they are also [illegible]. This is [illegible] dynamic action [illegible] and [illegible] groundmass [illegible] of the constituent [illegible]. The absence of such [illegible] from the dike rocks [illegible] reason for separating the coarser specimens [illegible] and possibly Archaean [illegible].

These [illegible] rocks will be considered under the heads of [illegible].

[illegible]

Some of the specimens [illegible] by Professor [illegible] from the [illegible] are [illegible]. They are numbered 1, 2, 3, 4, 5, 6, 7, 17 and 22. All are well preserved and [illegible] of their [illegible] which they exhibit [illegible] dynamic action [illegible] pyroxene or [illegible].

[illegible] — Numbers 1 and 2 [illegible] are rather [illegible]. Their [illegible] to the [illegible] dark green [illegible] cleavage [illegible] These [illegible]

* The terms porphyrite and porphyry [illegible] must be [illegible] as [illegible] in [illegible] sense, with [illegible] to [illegible] geologic age [illegible] and the specimens [illegible] which are [illegible] pre-Cambrian [illegible] In these cases [illegible]

rocks [illegible] of other [illegible] only fine-grained [illegible] almost every instance [illegible] [illegible] for this reason they will be [illegible] [illegible] page [illegible]

[illegible]

[illegible] — [illegible] Alaska. [illegible] number [illegible] by Professor Reid [illegible] other specimens [illegible] [illegible] They none of [illegible] purple [illegible] quartz [illegible] phenocrysts are altogether [illegible] [illegible] porphyrites.

[illegible] [illegible] [illegible] quartz [illegible] [illegible] This rock [illegible] groups of crystals [illegible] [illegible] [illegible] quartz and feldspar [illegible] [illegible] growth. [illegible] feldspar [illegible] rock. [illegible] [illegible] [illegible] [illegible] altered to chlorite.

[illegible] of Professor Reid [illegible] [illegible] phenocrysts [illegible] [illegible] The groundmass [illegible] [illegible]

Conclusion

Conclusion. — The conclusion is the last part of a composition, and should be carefully worked out. It is the summing-up of the whole matter, and should leave a definite impression on the mind of the reader. It is the place for the strongest arguments, the most striking illustrations, and the most powerful appeals. It is the last chance to make a good impression, and to drive home the truths you have been trying to teach. Many writers spoil their whole composition by a careless conclusion. They seem to think that anything will do for the end, and that the reader will be satisfied if only the beginning and middle are good. This is a great mistake. The end is as important as the beginning, and should be carefully planned and written. It should be clear, strong, and forcible, and should leave the reader with a distinct impression of the whole subject.

Exercises

Exercise. — Write a short composition on the following subject: "The Importance of Cheerfulness in Everyday Life." Be sure to have a clear plan before you begin to write. Divide your composition into paragraphs, and be careful to make each paragraph deal with only one point. Write a good introduction, and a strong conclusion. Be sure that your composition is correct in spelling, punctuation, and grammar. Have your composition ready to hand in on the day appointed.

[illegible] the granite mass. If [illegible] this rock [illegible] Tertiary [illegible] granite [illegible] was similar to that [illegible] which the [illegible] described [illegible]

The [illegible] of [illegible] rocks must [illegible] for the [illegible] of [illegible] to [illegible] No. 17, [illegible] throughout [illegible] the porphyrite. The [illegible] the latter [illegible] part of the [illegible] changed to [illegible] for the most part [illegible] crystalline, though exhibiting [illegible] of [illegible]. The [illegible] of plagio[illegible] throughout. The [illegible] crystalline [illegible] considerably in fineness, [illegible] 19, 25 and 26 [illegible] 34 [illegible] number 47 [illegible]. The [illegible] character of the [illegible] numbers [illegible]

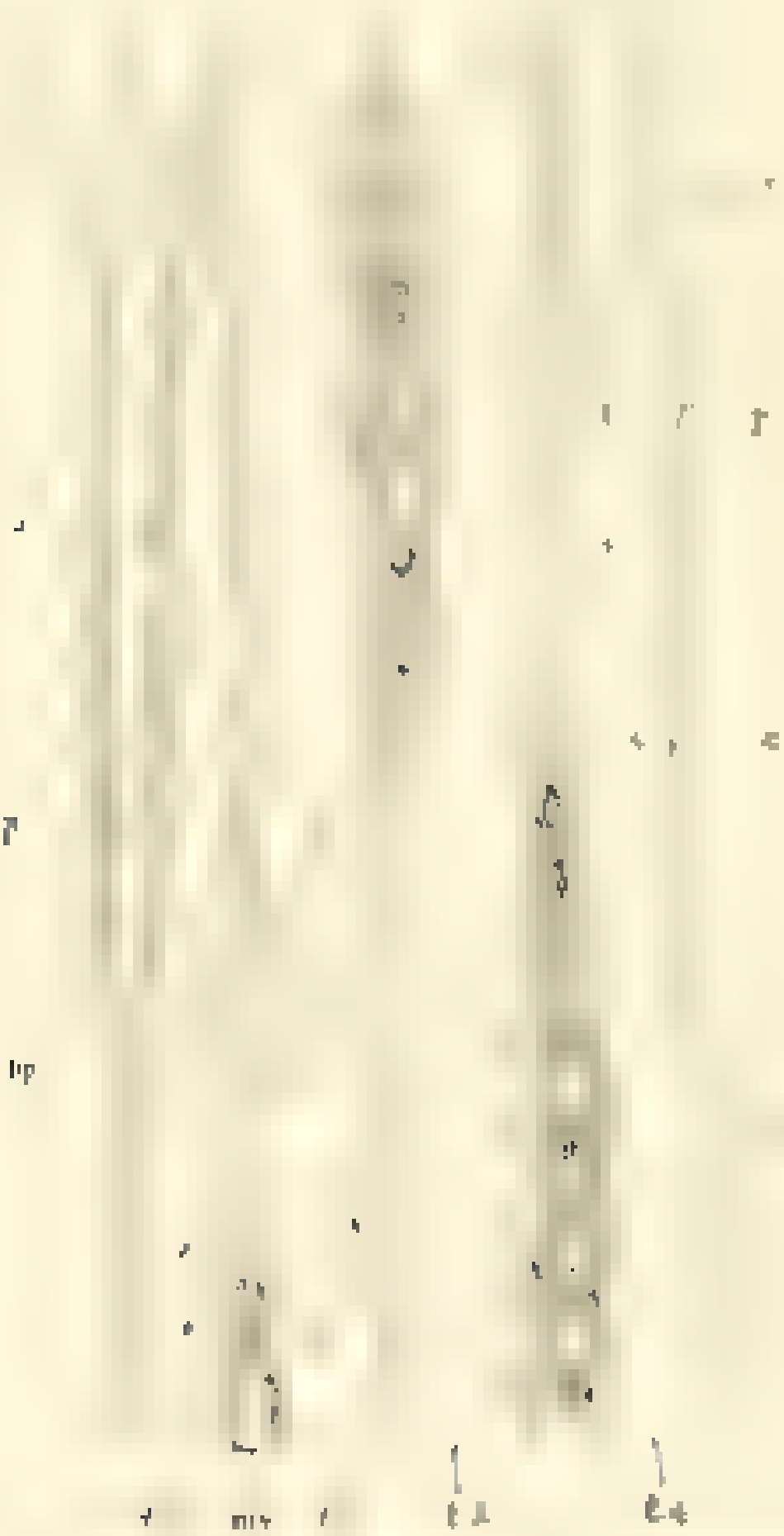
[illegible] from being [illegible] interest [illegible] grains of [illegible] by Mr. J. [illegible] by Mr. J. P. Iddings [illegible] and other rocks.[†] The rock [illegible] of brown [illegible]. The [illegible] consist [illegible]

[illegible] porphyrite [illegible].—[illegible] well known type of [illegible] porphyrite [illegible] so-called [illegible] among [illegible] is now known to have been extensively [illegible] purposes by the Romans at [illegible]

* Neues Jahrbuch für Min., [illegible]

† [illegible] Jour. [illegible], vol. xxx[illegible]

‡ [illegible] Geological Survey [illegible]



[illegible] with [illegible]. No such [illegible] could be detected in the buried forest specimens.

The medullary rays [illegible] are very [illegible], narrow and [illegible] structure, sheets of parenchymatous tissue. There are about [illegible] rays to the square [illegible] of surface [illegible]. The rays are [illegible]—that is, [illegible] broad, as in most conifers. The breadth of the ray is thus measured by that of the [illegible] cell, which is about [illegible]. The height of the rays varies from about [illegible] to [illegible] mm, and is from [illegible] cells. [illegible] medullary rays exactly fill the spaces between the [illegible] of wood fibers. In some cases the cell-walls of the [illegible] have undergone [illegible] contain the brownish deposit [illegible].

The transverse section shows parts of two annual rings [illegible] figure 5. In one the last growth—late summer [illegible]

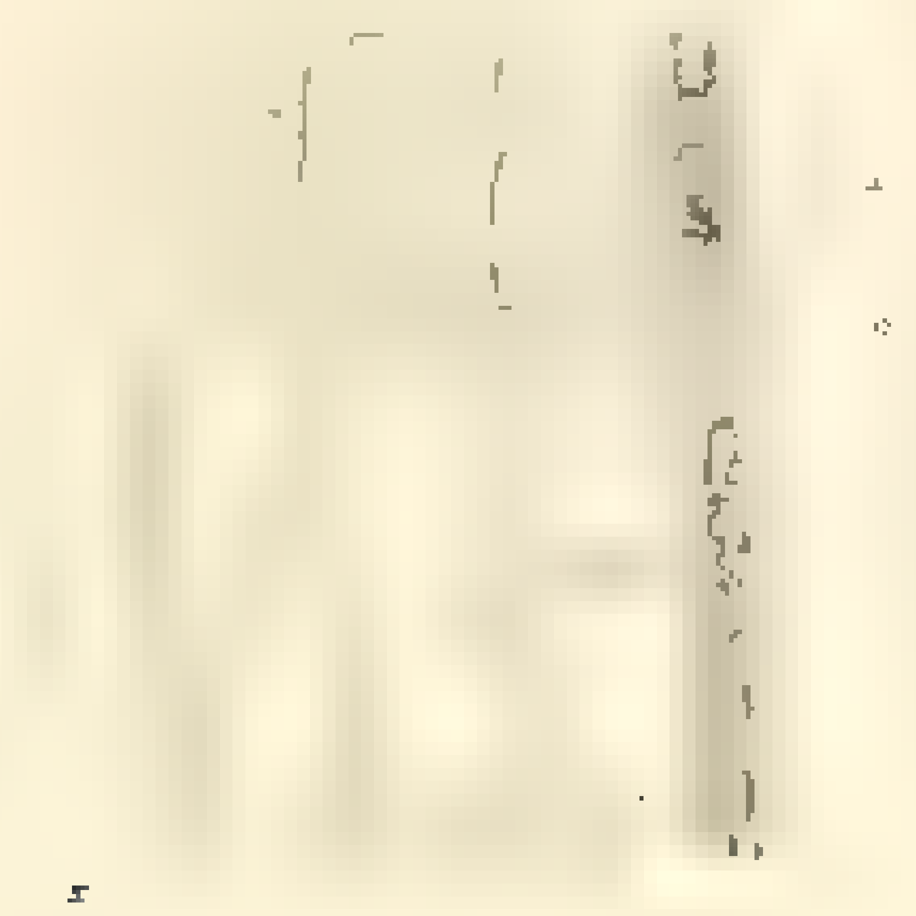


Fig. 5.—Transverse Section of Wood from the Buried Forest.

[illegible] representing later growth, [illegible] of successive [illegible] layers [illegible] growth [illegible]. [illegible] cells [illegible] Medullary ray [illegible] wall [illegible] of parenchyma [illegible] cavity [illegible] primary [illegible]

[illegible] the cells are [illegible] very thick walls, [illegible] the [illegible] are much larger [illegible]

[illegible]

[illegible]

Temperature and Rainfall Observations.

Mean temperature.	Maximum temperature.	Minimum temperature.	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

Barometer Observations at [illegible] Maine.

	Mean barometer.			Daily barometer.		
	7 a.m.	2 p.m.	9 p.m.	Mean.	Minimum.	Maximum.
July, [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
August	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Number of days on which .01 or more of rain fell.

July
August
September

Mean temperature at [illegible] Maine, July [illegible] August [illegible]

APPENDIX IV.

SUGGESTIONS TO FUTURE OBSERVERS

BY

G. P. BAKER

The accessibility and growing fame of Muir glacier make it certain that parties will frequently spend two weeks or a month there in future summers. They will have the opportunity of making observations of considerable interest.

The most important is the rate of recession of the ice-front. Maybe the easiest way of doing this is by taking photographs and comparing them with others taken earlier from the same points. These photographs should show the mountains behind. The following would be useful. A photograph of the northwestern corner of the ice-front taken from the beach close to camp Muir, the northwestern corner taken from the top of the bluff on the western side of the inlet, just south of the mouth of the glacial stream; the whole front taken from E, the front taken from F. This latter would show better than the others what changes have taken place and can be compared directly with plate II. F can be found without much trouble. It is the highest point in the neighborhood (3,800 feet), and lies N. 65° W., magnetic, from the peak of mount Wright. It is most easily reached by the stream between it and E (see map, plate I).

Compass bearings also will serve to determine the position of the ice-front. They should be taken on the corners and on any well-defined points of the ice-front. These bearings had better be taken from M and F. M can easily be found. It is on the projecting point of the bluff on the east side of the inlet near the edge. L is just opposite and bears N. 70° W., magnetic. The distance between them is 8,210 yards. From such observations the position of the ice-front can be immediately plotted on the map and the recession measured. Neither of these methods will yield very accurate results.

The map which I have made, though accurate so far as it goes, is far from complete. The upper parts of all the tributaries and much of the region between them is left blank. Any one with the proper training would find it very interesting to map these portions. Starting from the ground F and K his triangulation could easily be fitted to mine (see page 54). For such work I strongly urge the use of a plane table.

These suggestions are not, of course, intended for scientific explorers, but for persons of some scientific knowledge who may wish to add to the general pleasure of a stay at Muir glacier the special interest of a definite object, viz. to increase our knowledge of the region. I may say that a small piece of work done well, such as the mapping of a single tributary—e. g., Hart glacier, White glacier, or Variable canyon—is more useful than indefinite observations over a wider range.